NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS) INTERFACE DATA PROCESSING SEGMENT (IDPS)

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ABSTRACT

On May 5, 1994, President Clinton made the landmark decision to merge the United States' (US') military and civil operational meteorological satellite systems into a single, national system capable of satisfying both civil and national security requirements for space-based remotely sensed environmental data. For the first time, the US government is taking an integrated approach to identifying and meeting the operational satellite needs of both the civil and national security communities. The joint program formed as a result of President Clinton's direction is known as the National Polar-orbiting Operational Environmental Satellite System (NPOESS). Key to the success of the convergence process are continuing efforts to achieve commonality in the ground data processing segment across US government organizations, in particular within the Departments of Defense (DoD) and Commerce (DOC). The current plans are that five environmental data processing centers, as well as numerous globally-deployed remote field terminals will process the huge volume of satellite data expected to flow from the NPOESS converged satellite system.

Keywords: NPOESS, DMSP, POES, DoD, DOC, polar-orbiting, environmental satellites**,** data processing, IDPS

1. PURPOSE

The operational concept for the NPOESS Program is for the space segment to collect space, climatic, atmospheric, terrestrial, solar geophysical, oceanographic and other environmental data and transmit the data as Raw Data Records (RDRs) to Interface Data Processing Segments (IDPSs) collocated with remote field terminals and centralized processing centers. The NPOESS Integrated Program Office (IPO) is responsible for implementation of the following elements:

(1) The five main notional sensors that will fly aboard NPOESS: Ozone Mapping and Profiler Suite (OMPS); the Cross-Track Infrared Sounder (CrIS); Visible /Infrared Imager Radiometer Suite (VIIRS); the Conical Microwave Imager Sounder (CMIS); and the Global Positioning System Occultation Sensor (GPSOS). The other notional sensors INCLUDE: Advanced Technology Microwave Sounder (ATMS); Space Environment Sensor Suite (SESS); Earth Radiation Budget Sensor (ERBS);Total Solar Irradiance Sensor (TSIS); Altimeter (ALT); Data Collection System (DCS); and Search and Rescue Satellite Aided Tracking (SARSAT).

(2) The spacecraft vehicle that will carry these notional instruments.

(3) The ground system segment that will provide command and control of the NPOESS spacecraft.

(4) The ground data processing system that will deliver data and products to DOC, DoD and National Aeronautics and Space Administration (NASA), and other international users.

This paper deals primarily with the NPOESS IDPS. The purpose of this paper is to provide a description of the existing US polar satellite data processing environment and to outline NPOESS planning strategy that will

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transition the existing systems into a ground processing architecture environment that will provide operational access to the new and improved NPOESS data and products.

2. BACKGROUND

The United States Government has traditionally maintained two operational weather satellite systems, each with a 30-plus year heritage of successful service: the DOC's National Oceanic and Atmospheric Administration (NOAA) Polar-orbiting Operational Environmental Satellites (POES), and DoD's Defense Meteorological Satellite Program (DMSP). Recent changes in world political events and declining agency budgets prompted an examination of the feasibility of combining the two systems. In 1993, influenced by increased Congressional interest and following recommendations contained in the Administration's National Performance Review (NPR), NOAA, DoD and NASA began studying what it would take to converge the two systems. The completed study revealed that a converged system could reduce duplication, substantially reduce costs, and satisfy both civil and military requirements for operational, space-based, remotely-sensed environmental data. This tri-Agency (DoD, DOC, and NASA) study formed the basis for the development of the "Implementation Plan for a Converged Polar-orbiting Operational Environmental Satellite System," issued in conjunction with a Presidential Decision Directive (PDD), that set the stage for convergence.

The cornerstone of the overall convergence activity is the consolidation of DoD and DOC system requirements and the design and development of a single system to meet those requirements. The civil and military polar-orbiting operational environmental satellite programs have made significant strides towards convergence in the past three years. First, in May 1998 the DMSP and POES programs began command and control operations from one single ground facility at the Satellite Operations Control Center (SOCC), located in Suitland, Maryland. Second, a DMSP back-up SOCC facility was established at Schriever Air Force Base (AFB), Colorado. Third, three of the notional NPOESS sensors are at or near the award of a single contract for the sensor builds.

Key to the success of the convergence process is moving from today's similar yet distinct data ground processing systems to a future NPOESS architecture that will process the large volume of satellite data that the next-generation of environmental monitoring sensors will provide. It is not a case of "if you build it, they will come." The data processing centers will need to get both hardware and software ready to process the new satellite data streams while continuing to meet the existing needs of all their customers. In addition, the US must coordinate planning for the NPOESS IDPS with its partner, the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) because the EUMETSAT polar-orbiting satellite ((Meteorological Operational, MetOp) will occupy the third orbit in the NPOESS constellation. While the POES, DMSP, MetOp, and NPOESS systems are independent, they will all be serving an overlapping user community. Ultimately, these systems need to be integrated into the NPOESS IDPS planning process. This is an immense, complex problem.

## 3. INTERFACE DATA PROCESSING SEGMENT - Notional Description

So, what is an IDPS? An IDPS receives and stores RDRs and converts RDRs to Environmental Data Records (EDRs) before hand-off to the respective remote field terminals and processing centers that then integrate them into weather and other environmental products for transmission to end users. The NPOESS IDPS will consist of two components: (1) data processing functions which meet the requirements of "Centrals," and (2) data processing functions which meet the requirements of Field Terminals. A "Central" is defined as a satellite data processing facility which uses the full earth view of NPOESS satellite environmental data, along with data from other sources, to produce operational data products for distribution to its users in a timely manner. The NPOESS Centrals are currently identified as: the Air Force Weather Agency (AFWA), Offutt AFB, Nebraska; Fleet Numerical Meteorology and Oceanography Center (FNMOC), Monterey, California; Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, Mississippi; National Environmental Satellite, Data, and Information Service (NESDIS), Suitland, Maryland; and Air Force 55th Space Weather Squadron, Colorado Springs, Colorado.[6] Environmental data and products are received, processed, derived, and distributed to users around the US and the world on a 24-hour basis. The US military centrals must be ready to provide data for any point on the earth, as well as the space environment, on demand, 7 days a week and 24 hours a day. The U.S civil central must be ready to distribute data to the civilian national and international communities in both real-time and delayed modes. The NPOESS IDPS must be designed to meet user needs with minimum impact to existing receiver terminals and procedures.

Several other key terms and concepts must be defined to properly describe the ground data processing environment. The end-to-end processing of polar satellite sensor-derived data (including the remote field terminals) includes data ingest; data preprocessing; data quality and assurance; and data management (including data storage, distribution, and access).

Data ingest converts the received raw satellite data stream and associated telemetry and decommutes it such that data associated with individual instruments are stored on disk temporarily for further use.

Data preprocessing involves the conversion of raw instrument data into intermediate data records and subsequently into environmental parameters using pre-defined operational algorithms. The environmental parameter products may be derived from one or more of the sensors. Two types of environmental parameter products could be provided: those based on data from individual orbital passes for one or more instruments; and those gridded or spatially resampled to a specified earth coordinate system. Also included in the processing steps are computations of additional parameters and adjustments to correct the data for spacecraft and instrument-related effects, and to provide precise calibration and geo-location parameters for each instrument suite.

The performance of environmental data is continually validated at all processing levels for accuracy, precision and long-term stability. There are two functional levels of data quality and assurance: pre- and post-launch activities. IDPS preprocessing software encompasses the operational quality monitoring of data at each processing level to insure that the data represent true and reasonable values of the sensor measurements. The establishment of routine procedures within the IDPS environment is critical to early determination and swift resolution of anomalies that may occur in the space, sensor, or ground system segments. IDPS data management includes all the required support processing and functions needed to provide data and product storage and access, software and hardware configuration control, and database management. The operational distribution of and access to these data in a timely, reliable manner is paramount to the overall objective of the IDPS.
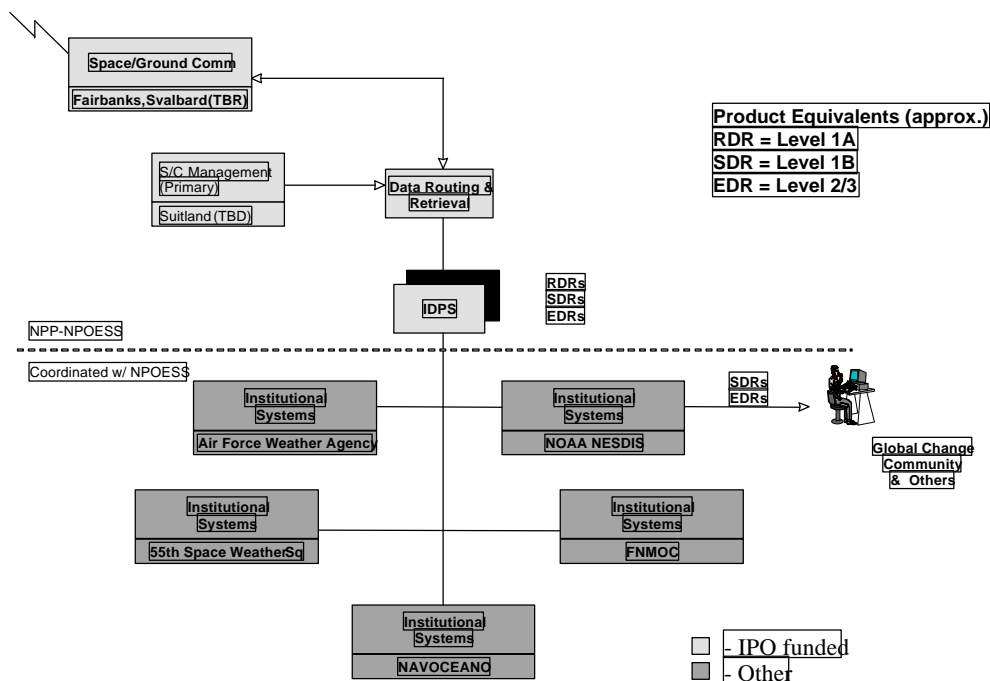
Figure 1: Notional National Polar-orbiting Operational Environmental Satellite System (NPOESS) Ground Data Processing System Architecture[15]

The international community has adopted various definitions for satellite data processing levels from the European Polar System and other various processing centers. The following notional definitions are based on the international standards.

Raw Data Records (RDRs) - Raw instrument data with all telemetry required for subsequent processing appended. Though the instrument data are unprocessed, the data may be reconstructed to some extent, in that communication artifacts, redundant measurements, etc. have been removed.

Temperature Data Records (TDRs) - Data from certain instruments, such as the Conical Microwave Imager Sounder (CMIS), are stored in terms of the antenna temperature of the measurement. No irreversible processing steps have been performed on these data, so that the raw instrument data can always be recovered from TDRs.

Sensor Data Records (SDRs) - Instrument data at full resolution have been time tagged, earth located, and quality controlled to a higher degree than RDRs (e.g. dead pixels flagged, etc.). Radiometric and geometric calibrations are computed and appended but not applied to the data (analogous to Level 1a format). An alternative form is instrument data which have been further calibrated radiometrically to engineering units (sometimes referred to as Level 1b). To the extent that it makes sense, it is desirable that the processing from RDRs to SDRs is reversible.

Environmental Data Records (EDRs) - Time tagged, earth located pixel values which have been converted to geophysical parameters. As described above, two forms may exist: geophysical parameters provided on an orbital or swath basis (Level 2) and parameters which have been resampled and referenced to a fixed earth coordinate grid (also known as gridded or Level 3 products). Appended to these data are ancillary files containing all quality, sensor, and extraction algorithm parameters needed for use of the data and derived products.

4. TRANSITION TO NPOESS IDPS

There are many similarities in the satellite ground data processing philosophies of DOC and DoD. In fact, both DOC's and DoD's existing satellite data processing systems, including hardware and/or applications software, effectively ingest and process satellite data and produce environmental products from both DOC's POES and DoD's DMSP satellites. While there are indeed many similarities, there are also distinct differences due to the fundamental differences in the civil and military missions. Convergence of the current two US polar-orbiting operational satellite programs and sensor requirements into one program in the early 21st century may simplify some aspects of processing, but will not change the fundamental differences in mission support. How does the NPOESS IPO plan to achieve commonality in ground processing at five distinct centrals with such diverse mission support requirements?

The first step toward the NPOESS IDPS is an in depth and detailed examination of the current satellite processing systems of the DOC and DoD. It is critical to the development of the NPOESS IDPS to leverage existing system capabilities and data processing and distribution infrastructures. These capabilities and future processing requirements must be independently reviewed such that a clear, technically sound acquisition specification can be drafted.

After a review of the current architecture, the second major task will be to properly describe the ground data processing of the centrals in the NPOESS era, circa 2005-2018. The IDPS must be capable of providing data products at several well-defined levels of processing and in formats specified by the user community. The timely and reliable distribution and access of operational data to users is paramount to the overall mission of the IDPS and the NPOESS program. The establishment of routine procedures within the IDPS environment is critical to early determination and swift resolution of anomalies that may occur in the space, sensor or ground system segments. The specifics of this information will go into a Ground Data Processing System Concept of Operations (CONOPS).

The third major step in the process is for the IPO, in conjunction with the US environmental data users, to draft and implement an NPOESS IDPS Transition Plan. The current projected launch date for the first NPOESS

spacecraft is circa 2009, with a launch readiness date of December 2008. There is more than sufficient time remaining to design, implement, and integrate an IDPS before the first NPOESS launch. However, the scope and magnitude of this effort in comparison with present day systems is immense. The estimated instrument data rates and projected number and volume of environmental parameters suggest that advanced planning and forward thinking will be required to assure the success of this effort.

4.1 CURRENT SYSTEMS DESCRIPTION

4.1.1 Department of Defense

Successful military operations require a reliable and timely exchange of accurate and relevant information between globally focused Strategic Centers, regionally focused operational data centers, and the battlefield focused warfighters. Assured communications with sufficient bandwidth to both fixed and tactical locations are crucial to military weather operations.[5] The US military heavily depends upon the DMSP satellites for worldwide continuous 24-hour/7 day per week operational weather support (figure 2). DMSP is the US DoD's current generation polar-orbiting operational environmental satellite system used for collection and timely dissemination of global environmental data to the DOD and other US government agencies.[2]
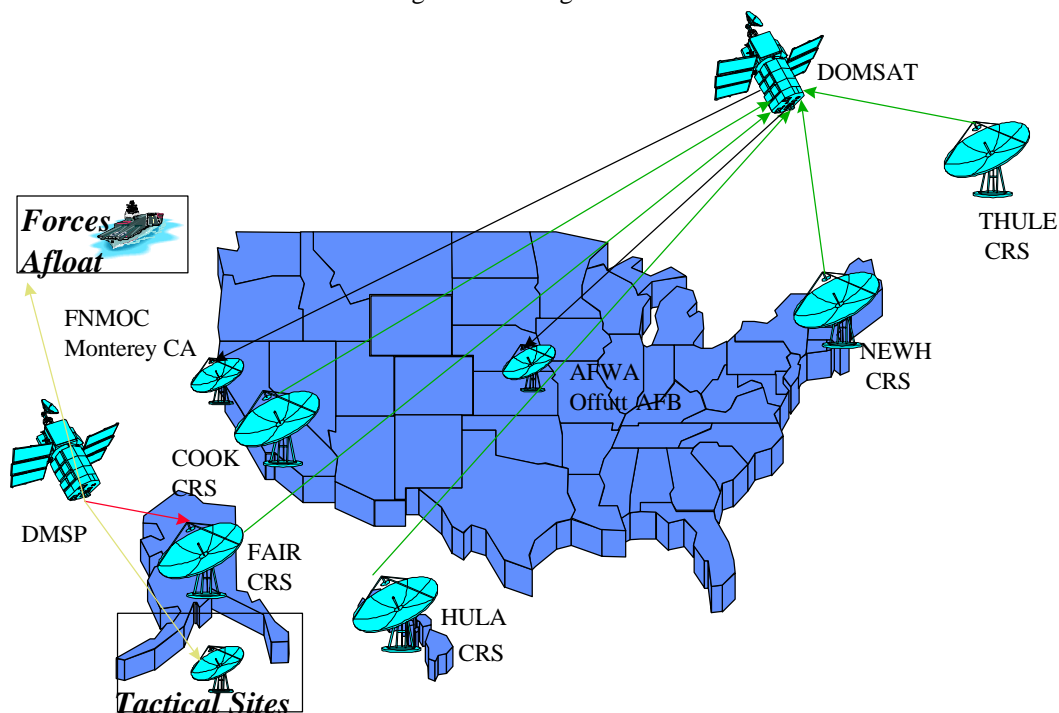
Figure 2: Defense Meteorological Satellite Program (DMSP) System Overview[2]

The DMSP Command, Control and Communications (C3) Segment conducts all mission planning, generates real-time and stored program commands, provides computer uploads to the Space Segment, and recovers and relays mission data to the User Segment[1]. DMSP C3 handles telemetry acquisition, processing and post-pass analysis, and provides the necessary communications between the C3 and User Segments at the Air Force Weather Agency (AFWA) and the Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC). DMSP data are transmitted in real time to tactical users or stored and transmitted once per orbit to AFWA and FNMOC.

The DMSP C3 segment is made up of many geographically separated elements, linked by communications networks. NOAA's Satellite Operations Control Center (SOCC) in Suitland, Maryland, is the primary satellite operations center for DMSP. The SOCC can communicate directly with the DMSP satellites through enhanced Remote Tracking Stations (RTSs). The Environmental Satellite Operations Control Center (ESOC) in Colorado

Springs, Colorado, is the backup control center for SOCC. Equipment installed at ESOC is identical to that installed at SOCC. In the event of a failure at the SOCC, the DMSP mission can be continued from ESOC.

The DOC and DoD share the use of the NOAA Fairbanks Command and Data Acquisition Stations (FCDAS) in Fairbanks, Alaska. The Air Force Satellite Control Network (AFSCN), Remote Tracking Stations (RTSs) at VTS (Vandenberg Tracking Station, California), HTS (Hawaii Tracking Station, Kaena Point, Hawaii) NHS (New Hampshire Station, New Boston, New Hampshire), and TTS (Thule Tracking Station, Thule, Greenland) are used to communicate with the DMSP satellites. Two dedicated communications networks and the shared AFSCN network provide communication between these sites. The primary communications path for transmission of DMSP data is the Domestic Satellite (DOMSAT). The current AFWA, FNMOC and NAVOCEANO IDPS systems are depicted in figures 3-5.
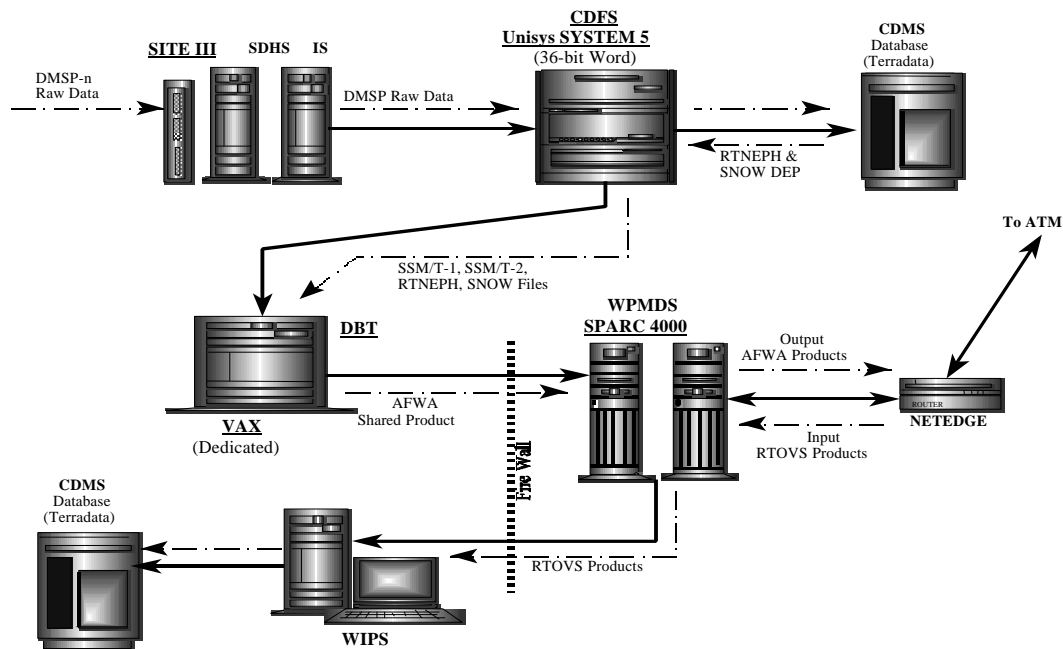
**Figure 3:** Air Force Weather Agency (AFWA) System Diagram[15]

4.1.1.2 Remote Tactical Field Terminals
Tactical military support is provided via the tactical remote field terminals which provide worldwide, real-time, tactical weather support. Field access to DMSP data is available through the Small Tactical Terminals (STTs); the Mark IV-B series of transportable terminals; the Integrated Meteorological System (IMETS); and the AN/SMQ-11 Shipboard Receiving Terminals[2].

The US Air Force's Small Tactical Terminal (STT) provides worldwide, real-time, tactical weather support to the Army and Air Force. The system consists of lightweight, portable weather terminals that provide an interactive meteorological satellite data analysis capability without reliance on surface communications. The system is configured in basic, enhanced, and Joint Task Force Satellite Terminal (JTFST) versions. The basic configuration of this system ingests, processes, stores, and displays Real-time Data Smooth (RDS) data from DMSP satellites; Automatic Picture Transmission (APT) data transmitted from the NOAA POES, the Chinese FENG YUN satellites, and the Russian METEOR satellites; and Weather Facsimile (WEFAX) data from the GMS, METEOSAT, and GOES geostationary satellites. The enhanced configuration of this system, in addition to providing the capabilities of the basic configuration, ingests, processes, stores, and displays encrypted and non-

encrypted Real-Time Data (RTD) from the DMSP satellites and High-Resolution Picture Transmission (HRPT) data from the NOAA polar- orbiting satellites. All configurations provide the capability to interface with the U.S. Army's Integrated Meteorological System (IMETS) and the Air Force Combat Weather System (CWS). The JTFST configuration of the system, in addition to providing the capabilities of the basic and enhanced configuration, ingests, processes, stores, and displays high resolution data from GMS, METEOSAT, and GOES. The JTFST configuration also will transmit raster images to a Satellite Imagery Dissemination System (SIDS).

The Mark IV-B system can access two types of polar-orbiting satellites (DMSP and POES), and three types of geostationary satellites Geostationary Operational Environmental Satellite (GOES), Geostationary Meteorological Satellite (GMS), and METEOSAT (European Space Agency geostationary meteorological satellite). It is capable of acquiring, ingesting, decrypting, and processing data from one polar-orbiting and one geostationary satellite simultaneously. The Mark IV-B provides mass storage backup and playback of raw satellite data and maintains a database for storing and retrieving meteorological information. It demodulates, decrypts, and processes the DMSP
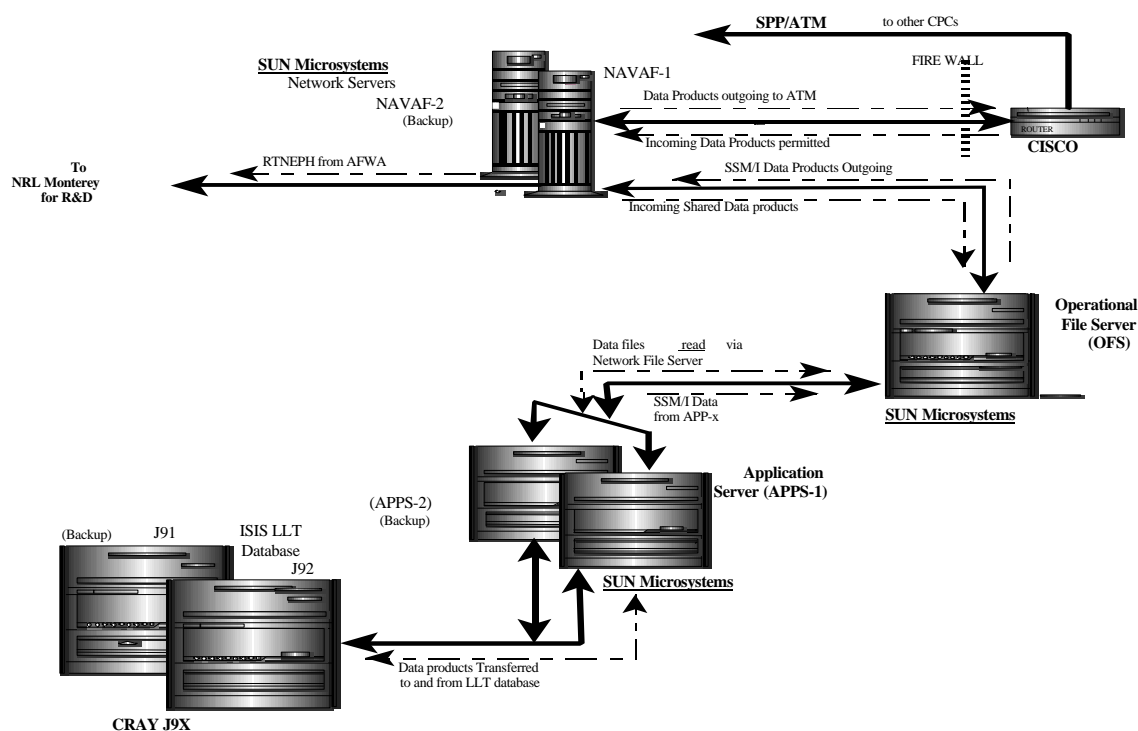
Figure 4: Fleet Numerical Meteorology and Oceanography Center (FNMOC)System Diagram[15]

real-time direct data stream containing visible (VIS) and infrared imagery (IR) data, as well as the Special Sensor Microwave/Imager (SSM/I), Special Sensor Microwave Temperature Sounder (SSM/T), Special Sensor Microwave Water Vapor Sounder (SSM/T-2) data received from DMSP satellites. The Mark IV-B is also capable of receiving and processing the DMPS Real-Time Data Smooth.

The Mark IV terminal, now used only by the U.S. Marines, is the predecessor to the Mark IV-B. It is a transportable satellite terminal designed for worldwide tactical deployment in hostile environments. This terminal has the capability to receive, process, decrypt, display, and distribute both infrared and visible high precision

imagery data in near real time from any of the DOD or NOAA meteorological satellites. These terminals also can archive data on magnetic tape in parallel with the ingesting, processing, and displaying of the data.

The AN/SMQ-11 Shipboard Receiving Terminal is a meteorological data terminal developed for U.S. Navy shipboard use. The system provides the Navy with secure, high-resolution, direct readout of visible and infrared imagery data transmitted from DMSP satellites, POES, and GOES Weather Facsimile (WEFAX) within 3 minutes of receipt from the spacecraft for use in tactical air support, antisubmarine warfare, and general weather information. The first 24 AN/SMQ-11 systems employ a dual Ultra High Frequency (UHF) planar-array antenna subsystem mounted on a single pedestal. One of the two arrays is used to receive data from DMSP satellites and the second is used to receive data from POES or GOES-WEFAX satellites, although not concurrently. System serial number 25 and all later systems employ a single UHF planar-array antenna subsystem mounted on a single pedestal. Antenna control provides stable, programmed tracking of polar-orbiting and geostationary satellites.

4.1.2 Department of Commerce
The POES consists of a combined space- and ground-based system used for collection and timely dissemination of global environmental data and products to civilian government agencies and other U.S. and international users. These environmental data consist of visible and infrared imagery and other specialized derived environmental parameters, including oceanographic, atmospheric, hydrologic and solar geophysical measurements and information.
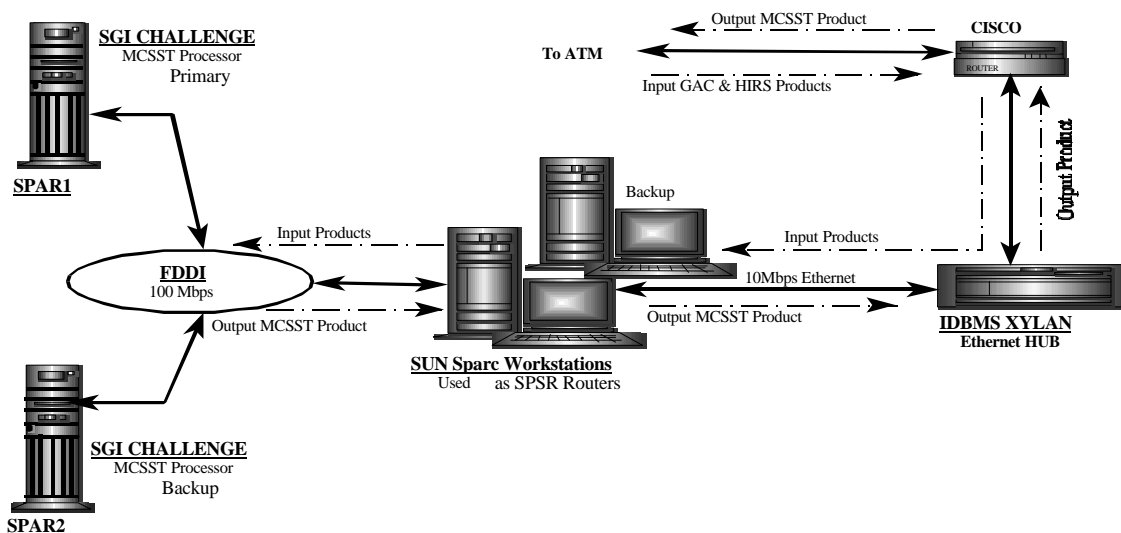
Figure 5: Naval Oceanographic Office (NAVOCEANO) System Diagram[15]

As the POES satellite orbits the earth, data are both broadcast continuously recorded on board for later playback. NOAA operates two Command and Data Acquisition (CDA) stations, one at Wallops, Virginia, and one at Fairbanks, Alaska, to receive both recorded and direct readout environmental data from the satellites. These data are relayed to the NOAA/NESDIS SOCC in Suitland, Maryland, and are subsequently transmitted to operational

ingest front-end processors (FEPs) for further processing (Figure 6). The applications residing on each of the FEPs are data driven processes. Incoming data are processed and formatted to generate level 1a data sets and staged via Fiber Distributed Data Interface (FDDI) and Enterprise System CONnection (ESCON) fiber based protocol data channels to the Central Environmental Satellite Computer System (CEMSCS) mainframe for level 1b processing, which includes earth location and calibration information for each instrument data set. Environmental data products are generated on CEMSCS and are distributed and archived, accordingly.

4.1.3 Shared Processing Program

Convergence of the NOAA/DoD ground processing segments has been preceded by over 20 years of interagency data sharing. The NOAA/DoD Shared Processing Program (SPP) was established in 1978 by Memorandum of Agreement (MOA).[3] The SPP provides a useful foundation for the development of a future NPOESS ground processing system. It provides for the exchange of polar satellite environmental data and products between the US' major satellite data processing centers. The MOA establishes four Core Processing Centers (CPCs), each sharing specific data and product processing responsibilities and also provides the basis for collaboration and coordination mechanisms required for the exchange of data between the centers. The four currently established CPCs and their major areas of processing responsibility are:

★   AFWA - Imagery and Cloud Analyses
★   FNMOC - Microwave Imagery and other products
★   NAVOCEANO - Global Sea Surface Temperatures
★   NESDIS - Satellite-derived Atmospheric Soundings
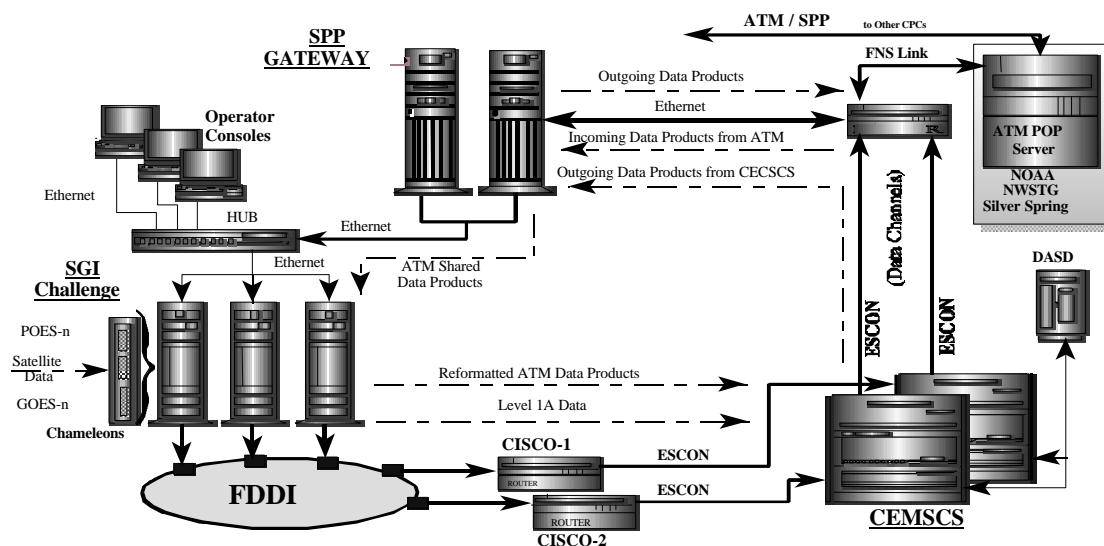
Figure 6: National Environmental Satellite, Data, and Information Service (NESDIS) System Diagram[15]

The daily operational exchange of data and products between CPCs began about 1985, using the shared, wideband satellite communications channels to transfer data between centers. Each CPC acquires and uses only those data and products of interest to their respective customers.

In 1996, taking advantage of newer communications technology, the SPP evolved its communications network media to the Asynchronous Transfer Mode (ATM) system, a nationwide telecommunications service (Figure 7). The ATM system offers its SPP users significantly higher bandwidth than the satellite channels with full duplex, push/pull capability. This capability offers greater network management flexibility than could be achieved with the shared satellite channel. Commercial off-the-shelf (COTS) software is used to drive the ATM system. The implementation of the ATM network in the SPP arena will influence the design, development, and implementation of the NPOESS IDPS. A degree of convergence has already occurred with respect to the ground processing systems. Four of the five NPOESS centrals are also CPC nodes established by the Shared Processing Program. As the United States moves toward the NPOESS era, the challenge will be to build upon the existing shared satellite data processing infrastructure that has been developed through many years of interagency cooperation and collaboration rather than take radical steps to rebuild the entire system. As the goal is to cause as little impact to the five (5) data centers and customer support process as possible. The existing infrastructure, from both a policy and architectural perspective will be strongly considered before any final IDPS architecture design decisions are reached.

4.2 Potential Architectures

The interface between IDPS processing and the processing performed by the users is a complex issue that is largely dependent on solutions that will be reached based on the following issues:

★   Physical location of IDPS hardware

★   Operational responsibility for producing EDRs

★   Responsibility for system hardware and software

★   Maintenance and configuration management
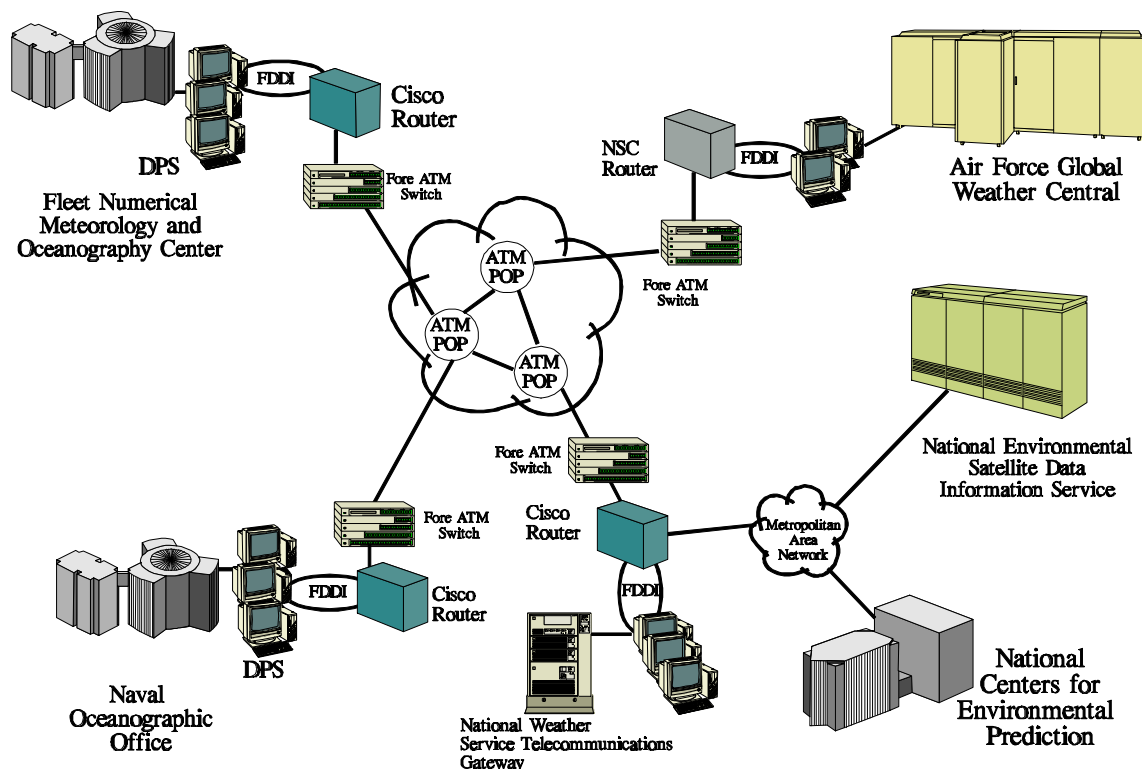
Figure 7: Shared Processing Program (SPP) Asynchronous Transfer Mode (ATM) Communications System[15]

Alternative approaches to the IDPS architecture may include, but are not limited to, the following notional concepts:

(1) Full Processing Capability at each Central.   In this concept, each central receives the full raw data stream and a single IDPS design is provided to each central site, with possible minimal modifications depending on central unique interface requirements at each site.

(2) National Satellite Processing Center. In this concept, a new National Joint Processing Center would be established for processing polar satellite data to a specified level.   Various agreed-upon levels of products, including an intermediate level product (between RDR and EDR), would be distributed or made accessible in near real-time; EDR products would also be made available to centrals and other users. The full satellite data stream would be received at one location, where products would be generated by a single IDPS. A backup satellite processing center would also be established.

(3) Distributed Processing.   In this concept, MOAs would be established with agreed-upon central processing locations. NPOESS Core Processing Centers (CPCs) would be established and assigned the responsibility of maintaining a subset of NPOESS EDR algorithms. This arrangement would leverage upon the existing NOAA/DoD interagency Shared Processing Program. The NPOESS software would be integrated into the CPC system, where the NPOESS data products would be configuration controlled, generated, and made available to other centrals, as required.

4.3 Future Challenges

The baseline acquisition strategy for NPOESS is to have a competitively selected, single prime contractor responsible for the total system performance to include the spacecraft sensors, spacecraft bus, ground segment, and delivery of data records to the NPOESS users. Until a single prime contractor is selected in circa 2003, separate NPOESS sensor development contracts will provide for early development of the primary sensors through a competitive prototype phase, that includes instrument design and development of science-level software that will produce environmental data records (EDRs). The early sensor development actions are also being supported with system studies. These studies encompass spacecraft design and development, ground systems, and IDPS-related work that will continue until a single prime contractor is selected for the engineering and manufacturing development (EMD) phase of the NPOESS program.

The challenge of integrating the NPOESS spacecraft, ground system, and IDPS components has been widely recognized as a vastly complex endeavor. As a method to demonstrate technological feasibility and reduce developmental risk inherent in the transfer from technology development to production systems, the NPOESS program is pursuing early prototype tests of candidate sensor capabilities for the operational NPOESS satellite.

4.3.1 NPOESS Preparatory Project (NPP)

The NPOESS Preparatory Project (NPP) is a joint mission of the NPOESS IPO and NASA. For NPOESS, this mission will provide for performance risk reduction of three critical NPOESS sensors: the CrIS; the VIIRS; and the ATMS.   For NASA, this mission provides continued science observations following the Earth Observing System Terra (morning) and PM (afternoon) missions and prior to the launch of the first operational NPOESS spacecraft. The NPP launch is planned for late 2005 into a 833 kilometer (km) orbit with a 10:30 a.m. equatorial crossing time at the descending node. The NPP system will provide operational agencies early access to the next generation of operational sensors, therefore greatly reducing the risks incurred during transition. This will permit testing of the advanced ground operations facilities and validation of sensors and algorithms while the current operational systems are still in place. This new system will provide nearly an order of magnitude more data than the current operational systems.

The ground stations, provided by the NPOESS program, will receive NPP stored-mission instrument data and route

this using NPOESS-provided communications networks for processing. The planned NPOESS IDPS will provide pseudo-operational processing of NPP instrument data for use by the operational and research communities to assess NPP instrument and operational algorithm performance. Additional processing capability provided collaboration with NASA, will support integration of these new data into climate models, calibration/validation trending analyses, and other higher level products.

5. SUMMARY

In spite of a number of complex issues associated with the design, development, acquisition, and implementation of a satellite system of the magnitude of NPOESS (including budget, programmatics, and technical feasibility), the U.S government's DOC, DoD, and NASA have made significant progress towards a successful convergence between the U. S. military and civilian weather satellite systems. As the NPOESS program advances into the development, launch, and operation of the satellite, the program must support the different mission requirements of the military and civilian communities. The IPO is fiercely committed to ensuring that the NPOESS program remains flexible enough to meet the needs of the entire joint international environmental data user community. This will involve increased planning efforts by the NPOESS program to form collaborative and cooperative relationships with EUMETSAT and other international partners. The following steps will ensure that convergence efforts achieve maximum success:

★ The ground system data processing, or IPDS, design and development must be given equal parity with development efforts of the spacecraft and sensors.

★ The NPOESS program must, on a continuous basis, fine tune user requirements into specifications that are clearly realistic, achievable, and affordable.

★ The NPOESS program must build an IDPS that can deliver data and products in a timely and reliable fashion, is accessible and useable for a wide variety of operational and research uses, and is easily maintainable and upgradeable (including new and improved algorithms).

NPOESS will provide a critically needed data and information source for operational weather and climate prediction, oceanographic forecasting, and environmental monitoring well into the next century. It will also provide new information the Earth system that will ultimately enhance the quality of life on this planet. Through combined and focused efforts of a cross-spectrum of national and international organizations, the NPOESS system can truly become the hallmark that was envisioned in the late 1980's.

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7. REFERENCES

1. SM-ALC Det 25, "Defense Meteorological Satellite Program Weapon System Master Plan", 1993.

2. Aerospace DMSP Overview WWW Website, www.aero.org/dmsp/overview

3. Robert J. Dumont, C. Nelson, D. Caviness, C. Thormeyer, D. Martin, J. Pereira, "Cooperation and Collaboration among the Nation's Meteorology, Oceanography, and Satellite Operational Processing Centers: An Evolving Era in U.S. Civilian-Military Partnerships", Bulletin of the American Meteorological Society, Vol. 77, No. 9, 1996.

4. HQ USAF/XOW, "Concept of Operations for Reengineered Air Force Weather", 1998.

5. Fred P. Lewis, "Air Force Weather Strategic Plan", Observer Magazine, Vol. 44, No. 7, 1997.

6. NPOESS/IPO, Integrated Operational Requirements Document, 1996.

7. Donald Blersch, Overview of Polar Satellite Programs, National Polar-orbiting Environmental Satellite

System (NPOESS), 14th International Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, Phoenix, AZ, American Meteorological Society, pp 146-148, 1998.

8. Memorandum of Agreement Between the Department of Commerce, Department of Defense, National Aeronautics and Space Administration for the National Polar-orbiting Operational Environmental Satellite System (NPOESS).

9. NPOESS/IPO, Employment Plan for Defense Meteorological Satellite Program (DMSP) Operations at the Suitland Satellite Operations Control Center (SOCC) Suitland, MD and Environmental Satellite Operations Center (ESOC) Falcon AFB, CO, Nov 1997.

10. White House, Presidential Decision Directive/NSTC-2, Convergence of U.S. Polar-orbiting Operational Environmental Satellite Systems, May 1994.

11. White House Office of Science and Technology, Implementation Plan for a Converged Polar-orbiting Environmental Satellite System, May 1994.

12. White House Memorandum, Presidential Decision Directives for Convergence and Landsat, May 1994.

13. NPOESS/IPO, Concept of Operations for Command, Control and Communications (C3) of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Program (C3 CONOPS), 1995.

14. NOAA Ground Systems Division (GSD) Website, http://osdacces.nesdis.noaa.gov/gsd1.htm.

15. NOAA/NESDIS/IPD, Program Operations Manual for the NOAA/DoD Shared Processing Program, 1998.